EXPLORING THE ROLES OF DIFFERENTIATED INSTRUCTION ON STUDENTS' COGNITIVE ENGAGEMENT AND ACHIEVEMENT IN CHEMISTRY

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Abstract: *The study investigated the roles of differentiated instruction on cognitive engagement and achievement among colleges of education chemistry students in South-West, Nigeria. Two research questions and two null hypotheses guided the study. Non-randomized Quasi-experimental design was used for the study. The population of the study was 240 year three students of chemistry in Federal Colleges of Education in South-West, Nigeria. A sample size of 180 students was purposively selected from three schools. Students' Cognitive Engagement Questionnaire (SCEQ) adapted from Barlow et al. (2020) and Chemistry Achievement Test (CAT) developed by the researchers, were the instruments used for data collection. These instruments were validated by three experts in Psychology, Chemistry, and Measurement and Evaluation, Faculty of education, University of Nigeria Nsukka. Internal consistency reliability coefficient of SCEQ was established using Cronbach Alpha technique as 0.82. Kuder-Richardson formula 20 was used to estimate reliability coefficient of CAT as 0.76. SCEQ and CAT were administered to the students with the help of the research assistants. Mean and standard deviation were used to answer research questions, whereas t-test was used*

to test the hypotheses at 0.05 level of significance.The result showed that the students taught chemistry using differentiated instruction improved in their cognitive engagement and achievement. The study also revealed that there were significant difference in the mean cognitive engagement and achievement scores of students taught with differentiated instruction and those taught using lecture method. It was recommended amongst others that Chemistry teachers should adopt the approach as it would foster improve cognitive engagement and achievement among Chemistry students.

Keywords: *Differentiated instruction (DI); achievement; **c**ognitive **e**ngagement; Chemistry.*

Introduction

The varied backgrounds of learners in developing nation like Nigeria present a number of multifaceted issues for chemistry teachers in formal educational settings (Saddhono, 2018; Maulana et al., 2020; Jabu et al., 2021; Marwiah & Pahar, 2021).To satisfy the demands of students with diverse chemistry learning styles and academic preparedness levels, teachers must use flexible teaching methods (Gelleset al., 2020; Jeong, 2022; Contrino et al., 2024; Subandiyah et al., 2024). Differentiated instruction (DI) is one such teaching method that is pertinent to meeting this need. In order to make learning more inclusive, the latter assists teachers in organizing learning procedures according to students' needs, interests, and learning profiles. It is anticipated that every student, regardless of differences, will be able to participate more actively in the learning process with this technique.

One way to help students with different needs understand difficult academic material is through differentiated instruction (Kado et al., 2021). As a result, a personalized approach is necessary for a diverse group of students. Therefore, in order to offer the best learning experience possible, teachers must intentionally plan for students' diverse learning abilities and change their teaching tactics. Differentiated learning is a pedagogical didactical strategy that gives teachers a starting point for addressing the various learning demands of their students (Chen & Chen 2019). Based on the evaluation of students' readiness or other pertinent student characteristics, such as learning preference or interest, differentiated learning is the proactive and intentional modification of the curriculum, process, product, learning environment, or learning time (Roy et al., 2013). It makes sense that the theories of differentiated learning approaches are

constrained by a number of guiding principles, such as emphasizing the key concepts and abilities in each subject area, being sensitive to individual differences, integrating assessment, and continuously modifying the process, content, and final products to suit the needs of the students (Rocks et al., 2008 as cited in Njagi, 2015). This suggests that teachers can improve students' motivation and performance by adapting their teaching methods to suit their preferred methods of learning. According to Vygotsky (1978), teachers should intentionally modify their lessons to fit each student's zone of proximal development, which differs from what the student can accomplish on their own and with scaffolding from more experienced individuals. Because the training will be customized based on the learners' development, this could benefit a variety of learners.

When students are presented with material that is too complex for them to comprehend, they become frustrated and may not participate fully. Students become demotivated to learn if the material is too simple or below their level of readiness, which leads to a chaotic learning environment (Morgan, 2014). There is proof that teachers who want to implement differentiated learning in the classroom will need to have teaching resources at their disposal or struggle to incorporate the approach into their classroom and carefully choose the content according to the students' proximal development level. Onyishi and Sefotho (2020) claim that many teachers worry about time constraints and a lack of resources, which prevent them from using differentiated instruction very often. The purpose of this research is to determine how varied instruction affects students' cognitive engagement and achievement in chemistry.

Academic achievement, which typically spans a number of disciplines, is the progress made towards the objective of gaining educational skills, materials, and knowledge (Akachukwu & Okoli, 2023). Instead of referring to the general acquisition of knowledge in academic contexts, it refers to achievement in academic settings. Mbaegbu and Osuafor (2023) define student academic achievement as the degree to which a student has met their immediate or long-term learning objectives. Academic achievement is a performance outcome that shows how well a person has achieved particular objectives that were the focus of the lesson. Therefore, Cumulative Grade Point Average (CGPA) is frequently used to record the grade or scores that students receive on general assessments and standard tests or examinations in a particular subject or course area (Dalaham, 2024). There are several reasons for the low chemistry achievement, but one of the main ones is the way that the subject is taught. However, little research has moved the emphasis from pedagogical problems to investigating psycho-

cognitive aspects associated with students' poor performance in chemistry. Dalaham stated that students' success in a variety of topics, especially at the secondary school level, has been found to be correlated with a number of variables, including motivation, emotional and social intelligence, creative thinking, social goal orientation, and engagement. It is unclear, whether cognitive engagement could be enhance through application of differentiated strategy in colleges of education in South-West Nigeria.

Akachukwu and Okoli (2023) define cognitive engagement as the degree to which learners are capable and willing to take on the current learning activity. This includes the level of effort that students are prepared to put into completing the assignment. While cognitive strategy use, absorption, and curiosity indicate the quality of cognitive engagement, attention, effort and persistence, time on task indicates the quantity of cognitive engagement. Although it has been demonstrated that students' cognitive engagement is correlated with significant educational outcomes, such as academic success and pleasure, little is known about how differentiated training in certain topics, like chemistry, could enhance cognitive engagement.

Over the years, many countries have been deeply concerned about students' achievement in different field. Chemistry as a subject is required at the senior secondary school level in Nigeria for applicants seeking to pursue careers in engineering, medicine, pharmacy, agricultural science, medical laboratory science, science education and other fields. Learners' learning and behaviour management needs vary, necessitating the employment of instructional approaches that are adapted to these demands. Research findings (Vanklaveren et al., 2017; Abbey, 2021) have indicated that differentiated learning has a stronger impact on students' learning outcomes. In a meta-analysis of differentiated instruction techniques in primary school, Deunk et al. (2018) found that when properly implemented, differentiated instruction has the potential to improve students’ outcomes. However, evidence supporting the benefits of tailored instruction is limited, particularly in chemical kinetics. Against this backdrop, this study looked into the impacts of differentiated strategy on chemistry students' cognitive engagement and achievement in Federal colleges of education in South-West Nigeria.

Statement of the problem

The goal of any teaching strategy used by educators is to raise student accomplishment. As a result, chemistry teachers can employ a wide range of methods in the classroom, including discussion, experimentation, and the direct (talk chalk) method. Teachers teach

their students in the typical, traditional manner and expect them to perform well, even though each student is unique and has different requirements, interests, learning styles, and profiles. Additionally, the majority of chemistry instructors now centre their classes on direct instruction since they think it is an adequate method of delivering learning experiences. Many students nowadays suffer as a result of the majority of chemistry teachers' methods, which do not take into account the differences among learners in the class, potentially impeding their ability to study the subject. To the best of the researchers' knowledge and empirical studies available, there is no data regarding the impact of differentiated instruction on the cognitive engagement and academic achievement of chemistry students in Federal Colleges of Education in South-West, Nigeria. This study examined effects of differentiated instruction on students' cognitive engagement and achievement in chemistry, in keeping with the stated research gaps. Thus, the question raised by this study is whether or not differentiated instruction can improve students' cognitive engagement and academic achievement in chemistry classroom.

Purpose of the study

In line with the problem of the study, the purpose of the study was to examine the roles of differentiated instruction on **c**ognitive **e**ngagement and achievement among colleges of education cchemistry students in South-West, Nigeria. Specifically, the study intends to:

1. determine the effect of differentiated instruction on students' cognitive engagement in chemistry.
2. ascertain the efficacy of differentiated instruction on students' achievement in chemistry.

Research Questions

1. What are the mean cognitive engagement scores of chemistry students taught using differentiated instruction and those taught using lecture method?
2. What are the mean achievement scores of chemistry students taught using differentiated instruction and those taught using lecture method?

Hypotheses

1. There is no significant difference in mean cognitive engagement scores of chemistry students taught using differentiated instruction and those taught using lecture method.
2. There is no significant difference in mean achievement scores of chemistry students taught using differentiated instruction and those taught using lecture method.

Methodology

The study's chosen research design is a quasi-experiment, more precisely the non-equivalent control group design. 240 third-year chemistry students from Federal Colleges of Education in South-West Nigeria made up the study's population. Purposively, 180 students from three different schools made up the sample size. The instruments used for data collection were the 20-item Chemistry Achievement Test (CAT), created by the researchers, and the 18-item Students' Cognitive Engagement Questionnaire (SCEQ), which was adapted from Barlow et al. (2020) and was structured on a four-point scale of Strongly Agree, Agree, Disagree, and Strongly Disagree. For every right answer, the achievement test question item received one mark. The marks allocated to the four-point scale of SCEQ were as follows: Strongly Agree (4), Agree (3), Disagree (2), and Strongly Disagree (1) for positive statements and vice versa for negative statement. Three specialists in the fields of psychology, chemistry, and measurement and evaluation from the University of Nigeria Nsukka's Faculty of Education verified these tools. Using the Cronbach Alpha technique, the internal consistency reliability coefficient of SCEQ was determined to be 0.82. The dependability coefficient of CAT was estimated to be 0.76 using Kuder-Richardson formula 20.

Experimental procedure

The experimental group received differentiated instruction in chemical kinetics from regular chemistry lecturers in each school during the study, while the control group received lecture-style education. The experimental and control groups were taught by the same teacher in the same school to reduce variations in delivery and style. In the experimental group, the teacher was thoroughly trained in the use of differentiated instruction (DI) strategies, whereas the lecturer in the control group continued to use the lecture method (LM). The creation of standardized lesson plans and frequent observations verifying that the instructor used the planned techniques faithfully throughout each group activity helped to preserve the intervention's fidelity. This made it possible to attribute the observed difference in students' outcomes to the teaching strategy rather than a particular teacher.

Method of data Collection

Three research assistants who taught chemistry in the Colleges of Education assisted in administering the study's instruments.

Method of data Analysis

The mean and standard deviation of the pre-test and post-test scores were utilized to analyse the research questions, and the t-test was employed to assess the hypotheses at the 0.05 level of significance.

Results

Research Question One: What are the mean cognitive engagement scores of chemistry students taught using differentiated instruction and those taught using lecture method?

Table 1: Mean and standard deviation scores for cognitive engagement of chemistry students taught using differentiated instruction (DI) and those taught using lecture method (LM).

Group scores		Pre-test		Post-test		Mean gain
	N	$\bar{X}$	SD	$\bar{X}$	SD	
DI	98	1.70	4.62	3.98	8.01	2.28
LM	82	1.25	3.10	2.20	7.31	0.95
Mean difference		0.45		1.78		1.38

According to the statistics in Table 1, the experimental group's pre-test and post-test mean scores were 1.70 and 3.98, respectively, with standard deviations of 4.62 and 8.01. On the other hand, the control group's mean scores before and after the exam are 1.25 and 2.20, respectively, with standard deviations of 3.10 and 7.31. Additionally, Table 1 shows that the treatment and control group's mean cognitive engagement gain scores were 2.28 and 0.95, respectively. This demonstrates that, in comparison to the control group, students who received tailored teaching scored higher on cognitive engagement in chemistry than those exposed to lecture method.

Hypothesis One: There is no significant difference in mean cognitive engagement scores of chemistry students taught using differentiated instruction and those taught using lecture method.

Table 2: T-test comparison of post-test mean scores for cognitive engagement of chemistry students taught using differentiated instruction (DI) and those taught using lecture method (LM).

Group	**N**	**Mean**	**SD**	**df**	***t*-cal**	**t-crit.**	**P-val.**	**Decision**
DI	98	3.98	8.01					
				178	2.07	2.01	0.03	Not Accepted
LM	82	2.20	7.31					

Table 2 shows that the T-critical value at the 0.05 level of significance is 2.01 with a p-value of 0.04 and the T computed value for the impact of differentiated teaching and the lecture technique on the cognitive engagement scores of chemistry students is 2.07. Consequently, the p-

value is less than 0.05 and the T-calculated value is more than the T-critical value. Thus, the null hypothesis (HO_1) is not accepted. In light of this, the researchers came to the conclusion that, when implemented correctly, differentiated education significantly improves student achievement in comparison to the lecture method.

Research Question Two: What are the mean cognitive engagement scores of chemistry students taught using differentiated instruction and those taught using lecture method?

Table 3: Mean and standard deviation scores for achievement of chemistry students taught using differentiated instruction (DI) and those taught using lecture method (LM).

Group		Pre-test		Post-test		Mean gain scores
	N	$\bar{X}$	SD	$\bar{X}$	SD	
DI	98	6.78	7.32	16.92	10.35	10.14
LM	82	6.32	6.25	11.02	9.48	4.70
Mean difference		0.46		5.90		5.44

The pre-test and post-test mean scores for the treatment group are 6.78 and 16.92, respectively, with standard deviations of 7.32 and 10.35, according to the data in Table 3. On the other hand, the control group's mean scores before and after the exam were 6.32 and 11.02, respectively, with standard deviations of 6.25 and 9.48. Additionally, Table 3 shows that the experiment and control group's mean achievement gain scores were 10.14 and 4.70, respectively. This demonstrates that students who get differentiated instruction outperformed the control group in chemistry.

Hypothesis Two: There is no significant difference in mean achievement scores of chemistry students taught using differentiated instruction and those taught using lecture method.

Table 4: T-test comparison of post-test mean scores for achievement of chemistry students taught using differentiated instruction (DI) and those taught using lecture method (LM).

Group	**N**	**Mean**	**SD**	**df**	***t*-cal**	**t-crit.**	**P-val.**	**Decision**
DI	98	16.92	10.35					
				178	2.36	2.01	0.04	Not Accepted
LM	82	11.02	9.48					

Based on table 4, the T-critical value at the 0.05 level of significance is 2.01 with a p-value of 0.04 and the T calculated value regarding the impact of differentiated instruction and the lecture method on

chemistry students' achievement scores is 2.36. T-calculated value is therefore more than T-critical value and p-value is less than 0.05. Consequently, the null hypothesis (HO_2) is not accepted. In light of this, the researchers came to the conclusion that, when applied correctly, differentiated education significantly improves students' achievement in comparison to the lecture technique.

Discussion

The study looked at how differentiated teaching approaches affected students' cognitive engagement and achievement in Chemistry. The study's findings demonstrated that students taught chemical kinetics concepts utilizing differentiated instruction had a higher cognitive engagement mean post-test score than those taught chemical kinetics using the standard approach. A t-test examination of post-test mean scores revealed that the difference between the two groups is statistically significant. This demonstrates that the increase in mean cognitive involvement is due to the intervention rather than chance. These findings are consistent with Subandiyah et al., (2025), who discovered that varied instruction has a higher and more substantial impact on students' cognitive involvement in Indonesian language learning. Furthermore, the findings of this study are congruent with those of Ramilo and Ting (2025), who discovered that differentiated instruction increased students' engagement and attentiveness in the classroom, with a considerable advantage over the traditional method.

The study's findings also revealed that students who were taught chemical kinetics concepts using differentiated instruction had a higher mean post-test score than those who were taught chemical kinetics through lectures. This demonstrates that the increase in mean achievement was caused by the intervention rather than by chance. A t-test examination of post-test mean scores reveals that the difference between the two groups is statistically significant. These findings are consistent with those of Subandiyah et al., (2025), who found that differentiated instruction has a bigger and substantial impact on students' progress in Indonesian language learning. Furthermore, the study's findings supported the findings of (Vanklaveren et al., 2017; Deunk et al., 2018; Kado et al., 2021), who discovered that differentiated learning improved students' learning outcomes with a significant advantage over traditional instruction.

Conclusion

According to the findings of this study, differentiated teaching, when applied appropriately, improves students' cognitive engagement and achievement in chemistry. This study looks at how varied instruction

affects students' cognitive engagement and achievement while learning chemistry. According to the study's findings, DI greatly improved students' cognitive engagement when compared to students in the control group who were taught using standard teaching method, as evidenced by post-test scores. On the other hand, the treatment class improved students' achievement more than the control class, as evidenced by significant changes in post-test scores.

Recommendations

Based on the results of the study, the following recommendations were made:

Teachers adopting this technique can boost students' cognitive engagement and achievement in chemistry.

Developing and updating chemistry curriculum using modern teaching methodologies like DI.

Conducting similar investigations in other science fields, including biology, physics, and mathematics.

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